[0136] In one aspect of this embodiment, each of the base current sources 426-1A through 426-1H may be implemented in a conventional manner using MOS transistors, wherein the current provided by each base source is determined by the control voltage 469 (V_{CTRL}). For example, in one exemplary implementation, the control voltage V_{CTRL} may be applied to all of the base current sources such that a particular control voltage provides a corresponding current from each base source (e.g., a control voltage of 0.7 to 3.3 Volts generates a corresponding current in each base source of from 0 to 1.3 milliamperes). It should be appreciated that, in different implementations, the control signal V_{CTRL} may be varied to provide for variable base currents or alternatively may be held constant (e.g., connected to Vdd).

[0137] Furthermore, it should be appreciated that although the variable current source 420-1 shown in FIG. 16 is configured to provide eight different current levels, the present disclosure is not limited in this respect; namely, a general configuration similar to that shown in FIG. 16 may be implemented to provide a different number of current levels based on multiple base current sources, which may be selectable via a decoder similar to that shown in FIG. 16 by digital signals having an appropriate number of bits based on the number of current levels to be provided. In yet other embodiments, a pulse width modulation technique may be employed using a single base current source to provide the variable current 470-1. In such embodiments, a fixed current provided by a single source is pulse width modulated to have different duty cycles, wherein a relatively lower duty cycle represents a lower average current and a relatively higher duty cycle represents a higher average current. In one aspect, the number of possible duty cycles to provide different average current levels may be determined in a manner similar to that employed in the configuration of FIG. 16, wherein digital binary coded signals applied to a decoder provide for a number of different possible duty cycles, and hence different currents.

[0138] In the embodiments discussed above in connection with FIGS. 13-16 various field control components, including variable current sources, switching and multiplexing components, logic gates, and the like, are employed as a "digital switching network" that effectively controls and distributes current in the microcoil array 200B. In one aspect of these embodiments, such a digital switching network makes control of the array 200B more practicable, especially in implementations in which the number (N^2) of microcoil cells 250 may be significantly large; more specifically, current may be time-shared in a multiplexed manner amongst multiple microcoils, and a relatively small number of digital signal inputs may be employed to control the entire microcoil array. With reference again to FIG. 13, again the signals required in this embodiment to provide for array control and facilitate sample manipulation include a clock signal 462, three column select signals 464, three row select signals 462, twelve current level signals (i.e., three signals for each of four variable current sources, as indicated by the signals 468-1 for one of the current sources), a control voltage 469 (V_{CTRL}) for the current sources, and a direction (polarity) signal 472. As discussed above, any one or all of the foregoing signals may be provided by one or more processors 600, as shown in FIGS. 1 and 2, such that these signals may be generated pursuant to programmable and/or user-selected computer control.

[0139] In FIGS. 13-16, the various control signals generally are provided such that one microcoil of the array is enabled at any given time to generate a magnetic field having different possible field strengths based on the variable current passing through the microcoil. Accordingly, in one aspect of this embodiment, to generate multiple magnetic fields to effectively trap or move multiple samples "simultaneously," different microcoils of the array are sequentially enabled (i.e., current to the microcoils is multiplexed) on a time scale that is significantly faster than a "reaction time" of the samples to the presence or absence of a magnetic field. In this manner, sequentially generated magnetic fields may appear to be simultaneously generated to the samples in question. Multiple microcoils of the array may be sequentially enabled (e.g., under computer control) on an appropriate time scale according to any one of a variety of "scanning protocols;" for example, in one exemplary implementation, a conventional "raster scanning" protocol may be employed to sequentially enable each microcoil of the array on a row by row basis, starting from the top left corner of the array shown in FIG. 13 and proceeding to the right along the first row, and then to the second row, etc.

[0140] To provide some exemplary illustrations of appropriate scanning time scales for sample manipulation, a commercially available magnetic bead (e.g., Dynabead) having a diameter of approximately 4-5 μm is considered in a liquid water environment as a representative magnetic sample. In general, samples suspended in a liquid experience a viscous drag as they move through the liquid; this viscous drag generally affects the speed with which a sample reacts to an external magnetic field (and hence the "response time" of the sample). For a magnetic sample suspended in a liquid, the response time τ_{cutoff} is given as

$$\tau_{cutoff} \approx O(\mu\mu_o/\chi B^2), \tag{2}$$

where μ is the dynamic viscosity of the liquid. Accordingly, if the sample is exposed to a pulsed magnetic field having a frequency that is significantly higher than the sample's "cutoff frequency" (i.e., the reciprocal of the sample's response time), the pulsed magnetic field appears to exert an essentially continuous average magnetic force on the sample. In this manner, one current source may be multiplexed amongst multiple microcoils of an array (i.e., sequentially applied in time) at an appropriate rate to generate seemingly continuous magnetic forces from the perspective of the samples in question. The magnetic force resulting from a magnetic field was discussed generally in connection with Eq. (1) above. For a Dynabead in water having a diameter of approximately 5 μm under a magnetic field on the order of 30 Gauss, the response time T_{cutoff} is on the order of 10^{-2} seconds. Using a pulsed magnetic field having a frequency greater than the reciprocal of the sample's response time (e.g., >approximately 100 Hz), the resulting force is equal to the product of the duty cycle and the force given by Eq. (1).

[0141] Once a sample is attracted to a local magnetic field, a sufficient magnetic potential energy must be maintained to trap the sample in the field. In particular, a sample suspended in a liquid moves chaotically due to random collisions of the sample with the surrounding liquid molecules, a phenomenon known as Brownian motion. Such Brownian motion can lead to diffusion of the sample; with random velocity, the sample can move in a random path (e.g., in a tangled zig-zag manner) away from its location at any given time due to